The Mechelecciv

VOLUME 21 DECEMBER 1962 NO. 3

THE GEORGE WASHINGTON UNIVERSITY

DECEMBER 1962

We went to the mountain to make 1963 Ford-built cars go 30,000 to 100,000 miles between major chassis lubrications

Quite a task faced Ford Motor Company engineers when they set out to eliminate the traditional trip to the grease rack every 1,000 miles.

Like Mohammed, they went to the mountain—Bartlett Mountain on the Continental Divide in Colorado. More molybdenite is mined there than in the rest of the world combined. And from molybdenite ore comes the amazing "moly" grease that helps extend the chassis lubrication intervals for Ford-built cars. This grease sticks tenaciously to metal, stands up under extreme pressures and resists moisture, pounding and squeezing. It is slicker than skates on ice!

New, improved seals were developed. Bushings, bearings and washers of many materials were investigated. Slippery synthetics, like nylon and teflon, were used a number of new ways.

The search for means to extend chassis lubrication also led to New Orleans—where experimental suspension ball joints tested in taxicabs in regular service went two years without relubrication.

It took time. And ingenuity. But the effort paid off when Ford-built cars were the first to build in chassis lubrication good for 30,000 miles or two years—whichever came first.

Another assignment completed—another "Ford First" and another example of how Ford Motor Company provides engineering leadership for the American Road.

Ford
MOTOR COMPANY
The American Road, Dearborn, Michigan

PRODUCTS FOR THE AMERICAN ROAD • THE HOME
THE FARM • INDUSTRY • AND THE AGE OF SPACE

Editorial Page

A Matter of Duty

An engineering student desiring to obtain an engineering education must sacrifice many pleasant diversions. Large amounts of study time required for satisfactory comprehension of an engineering course interfere drastically with a full social life. As if that were not enough, the additional twenty credit hours required of engineering students further increase the burden. However, the engineering student's concern over these matters may cause him to overlook another salient consideration.

It is important to realize that the sacrifice rests not entirely with the student. Considerable sacrifices must be made by society to permit the education of future engineers. An observation of the two hundred engineering schools in this country will attest to the magnitude of the sacrifice. The value of real estate and equipment alone cannot be dismissed lightly. In addition, teachers and professors of the engineering schools could apply their skills elsewhere if there were no need for engineers. Not to be overlooked is the large number of engineers and engineering students who could be diverted to other productive work if they were not needed in engineering. Therefore, the sacrifices made by society carry with them certain obligations.

Perhaps the first stipulation is the students obligation to approach his course with the attitude of bettering himself by the knowledge acquired. It is not feasible or desirable to force a student to learn, so the responsibility must rest with the individual. Of course, good study habits are important but the optimum approach includes more than just study habits. The engineering student should want to learn course material because it will benefit him and make his contributions to society more valuable.

Another important consideration is a student's choice of courses. Under the new curriculum, he will have a greater possibility of getting a better education. However, it is possible that a student might misuse his privilege and not better his educational achievements. It is imperative that a student choose courses coherently to provide himself with the best possible education. This criterion should be applied not only to engineering courses, but to electives as well. A student not taking a well planned program of electives can hinder his chance of getting the sound liberal background which is so important in modern society.

Each engineering student should realize the significance of improving the environment of his fellow man. If he feels this way, he will do his best to provide benefits for others. This means facing squarely the problem of getting the best education possible and not following a less demanding course. After having completed his education, he then will be able to cope fully with the task of improving the status of his fellow man.

--D. L. J.

the Mecheleciv

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ARTICLES

DEPARTMENTS

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It is a source of pride to witness the pioneering work which Dean Mason and his colleagues have done in developing the exciting new undergraduate program for the School of Engineering and Applied Science. It is a program which I hope other segments of the University will study closely in re-developing their own programs.

The notion that a student should proceed at his own pace, and that a minimum of bureaucratic impedimenta should confront him in the process, has been given much lip service, but little practice in most of our professional schools. Instead, there has been a proliferation of departments and curricular requirements which have resulted in greater narrowing and specializing of the student's experience in order to meet the designated "required courses." This University believes that a person trained in a professional field should be also educated in this field. This necessitates flexibility in planning each student's academic program, and encouragement to the student to broaden his fields of knowledge by drawing upon all parts of the University for his educational experience.

Dean Mason expressed this thought very well when he recently said: "This program recognizes the individual student as the most important single element in the educational process. As individuals are distinctive, there can be no single educational formula or pattern by which the student moves toward professional competence."

In today's world, professional competence is contingent upon both breadth and depth of educational experience. Just as the student of the social sciences should inform himself about the essentials of the physical sciences, so the student in the physical sciences should inform himself about the social sciences and the humanities. This University is dedicated to doing all that it can conceptually and programatically to achieve this desirable educational goal. I sincerely hope that as you participate in this new approach to education, you will come to believe firmly that we are realizing this objective.

—Thomas H. Carroll

A new and unique approach to education in engineering and applied science, to be instituted at the George Washington University, was formally announced on November 8, 1962. The new curriculum, the first of its kind in the United States, will allow students to keep pace with advances in the numerous areas of engineering and applied science, while acquiring the most liberal education ever made available in these fields.

Those who register for the first time during the fall semester of 1963 will follow this new curriculum. Initially, they will be concerned with correlating previous training along certain lines with the need for further education in those areas. Some students may be required to take preparatory or remedial courses under a provisional admittance. Others may be able to waive as many as 15 credit hours or more for advanced standing. Faculty advisors will help students in this matter as well as matters involving selection of courses of study. Since there is no set curriculum of required courses to be taken, students will have a wider range of studies to follow and greater freedom in choosing those areas in which they will concentrate their academic efforts. In this way, each student receives an individualized pattern of instruction.

During the Introductory and Intermediate levels, requiring the completion of 70 and 35 hours respectively, the student will take courses in applied science, in engineering, and in liberal arts, giving him a more liberal basic education plus a firmer foundation for the specialized instruction that he will receive during his 35 hours of study in the Advanced level. When the student reaches this level, he is then ready to turn his attention to courses of instruction in the area of his choice. Accordingly, he will receive his Bachelor of Science degree with one of the following major fields of interest:

Civil Engineering	Engineering Science
Communications	Machine Computers
Control Systems	Measurement Science
Electrical Engineering	Mechanical Engineering
Electronics	Structures
Energy Conversion	Theoretical and Applied Mechanics

The ability of each student to continue into a new level is determined by a week-long evaluation period between the Introductory and Intermediate levels and between the Intermediate and Advanced levels. Throughout the entire week, no grades will be given. Students will be placed in one of three main categories, according to how well he comprehends and presents the required material:

(1) Those who will be advised not to continue in the study of engineering and applied science.

APPLIED SCIENCE

(2) Those who will advance to the next level, with the stipulation that they take courses which will give them a firmer grounding in some specific area.

(3) Those who will advance to the next level unconditionally.

Each student will be assigned practical problems in engineering and applied science. The emphasis of the problems will be placed on capability to handle situations that might be encountered after graduation; therefore, students will not have as great a time limitation imposed upon them as, for instance, for exam problems. Also included in the evaluation will be an appraisal of the student's intellectual powers, and of his ability to intelligibly communicate his ideas to others. In general, then, the topics explored will concern the basic fundamentals, technical and non-technical, that each student should know in order to fully comprehend the ideas that he will encounter in the next succeeding level.

It is anticipated that the new curriculum will attract more students toward an education in engineering and applied science. However, greater caution should be exercised in selecting students to be enrolled in this curriculum. It demands a more mature person, one who has a greater sense of responsibility, as expressed by Dean Martin A. Mason of the School of Engineering and Applied Science:

> "A student is given much personal freedom, but freedom tempered with responsibility to accept the consequences of his actions and decisions, and restrained by the ethics, practices, and rules of the profession he is preparing to enter."

This theory applied not only to new students who will enroll in 1963, but also to those now registered in the School. These students have a choice -- either to remain in their present curriculum or to change to the new one. The decision should be based upon which curriculum best suits the type of education the individual requires. The old curriculum provides a greater coverage of the more general aspects of the engineering fields (M.E., C.E., EE.), while the new system covers more areas of interest by providing finer breakdowns or separations of specific engineering fields. This means that a student interested primarily in computers, for example, can now concentrate more effort in that area if he switches to the new curriculum under a degree in machine computers. At the same time, a student interested in the widespread and varied applications of basic civil engineering fundamentals would remain in the old curriculum with the ultimate goal of a civil engineering degree.

--Continued on Page 8

"This may well be the most significant development in engineering education in its American history". So I wrote during the lengthy considerations that preceded formal adoption of our new approach to education of engineers and applied scientists. The wide interest and favorable comments following our public announcement of the new program have strengthened my opinion that we are indeed leading the way toward major change in American engineering education.

Engineering education has reached an impasse. Modern technology, the dominant force in today's civilization, demands of the professional engineer and applied scientists social, political, cultural and technical competences far beyond the capability of our traditional engineering curricula to supply them. We, as most other progressive schools, found ourselves in the midst of a chaotic game of academic musical chairs, deleting this course to add some other, compressing, expanding, and subtracting in an endless attempt to include the important and yet not lose the necessary. Throughout we recognized that despite our best efforts we were not satisfying the real needs of the student or the profession.

Some three years ago I concluded we at GWU could and must develop a new pattern of engineering education. We needed a new approach to educational preparation for those who as engineers or applied scientists would apply knowledge to satisfy man's needs for security and comfort. I sought to restore the student to his proper place as the single most important element in the educational process, to satisfy the professional need to know man as well as machines, and to present the student opportunity to develop his full potential as an individual.

Faculty discussions were begun; ideas were explored, discarded, modified; the problem was defined and redefined; and finally we hammered out the basic pattern of our new approach. Then about a year ago the Dean's Council began the task of translating the patterns into a practical and acceptable working reality. Almost all the faculty participated directly in this phase; all the faculty contributed to the development. Those deserving particular recognition for their contributions during long and often difficult hours of Dean's Council discussion are Dean Grisamore, Prof. Crafton, Prof. dePian, Prof. Ojalvo, Prof. Walther, Prof. Naeser, Assoc. Prof. Kaye, Assoc. Prof. Fox, and Assoc. Prof. Murdaugh.

I welcome with you the exciting and challenging opportunities of our new program. Each undergraduate now has the freedom and the duty to himself to use these opportunities to good advantage. We state, and we mean it, that the student is the focus of all our effort, but he must be a dynamic and aggressive partner in the effort. Never before in engineering or science education have you had such opportunity; never has the challenge to you been so great and the reward so promising.

—Martin A. Mason

COMPUTERS FOR

Cams are frequent and essential components of many types of machines. They are commonly utilized to provide unusual or irregular motions which would often be impossible with any other type of linkage. Cams are found in such devices as the internal combustion engine where it is used in connection with valve operation; in automatic lathes, record changers; linotype machines; automatic screw machines and spinning and weaving machinery.

Now that some of the uses have been established, it would be desirable to define what is meant by cam mechanisms. In its simplest form a cam mechanism is composed of three links — the cam, the follower and the frame. The cam is a link having an irregular surface or groove that imparts motion to a follower. The follower is a link which is driven by the cam and the motion of which is produced by contact with the cam surface. The frame is the link that guides and supports the cam and follower. The cam, which drives the follower, usually rotates with constant angular velocity although some cams move in rectilinear translation. The desired motion of the follower is the output for which the design of the cam is aimed.

Cams usually are designed in the form of discs or cylinders, but occasionally they take other forms. Cams are usually divided into six general classes as -- translation cams; disk cams, sometimes called radial cams; cylindrical cams; conical cams; spherical cams; and three-dimensional cams. This paper will only be concerned with disk cams because they are the most commonly used. In addition, they lend themselves more readily to a discussion of the general theory of cams and, once the general theory of the disk cam is mastered, it is easy to extend the principles to any type of cam.

The follower is not to be overlooked in importance because the whole purpose of the cam is to impart the desired motion to the follower. Most cam followers, particularly on radial cams, are held against the cam profile by springs or by gravity. The follower may vary greatly in design. It can consist of a point or knife edge, a rounded or curved surface, a roller, or a flat surface. The flat follower is quite common since it is used in automobile engines; however, the most widely used follower is the roller follower. The roller follower is very popular because of low friction losses and it facilitates easier cam design.

One notable problem encountered with the use of a roller follower is large pressure angle. (See Figure 1) The pressure angle is the angle between the instantaneous direction of follower motion and the normal to the working curve. Any time that a large pressure angle is encountered, a considerable sidewise force on the follower will result. It is not difficult for the sidewise force to cause jamming and even breakage of the follower. As a result of empirical studies, the pressure angle is usually limited to 30 degrees. In some cases this number can be exceeded, but considerable care should be exercised in the design.

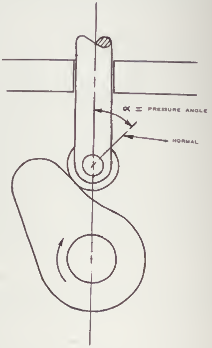


FIGURE 1. PRESSURE ANGLE

The study of the cam mechanism is most easily done graphically. Of main interest is the motion of the follower as it moves over the surface of the cam. The follower motion is usually given as a function of the position of the cam. The graph with the follower motion as the ordinate and the cam position as the abscissa is called a displacement diagram. (Figure 2) Displacement diagrams include one cycle of cam operation. If the cam rotates with constant velocity, this curve would be called a displacement-time curve because equal displacements of the cam correspond to equal time increments.

Figure 2 is a displacement diagram showing rise and fall incorporating simple harmonic motion. This motion was chosen for Figure 2 because it is the most basic curve and it still illustrates the principles under consideration.

CAM DESIGN

by Douglas L. Jones

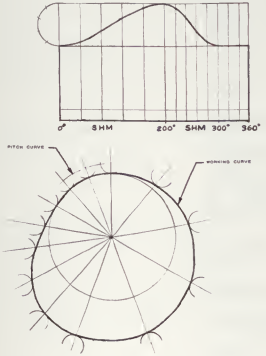


FIGURE 2. GRAPHIC DESIGN OF CAMS

The displacement diagram shows a rise of one inch in 200 degrees using SHM and a fall of one inch in 100 degrees also using SHM. The last 60 degrees is a dwell during which there is no rise or fall.

The criterion used in cam design is that a specified follower motion is to be obtained. Once the type of follower motion is chosen, the displacement diagram is determined. Therefore the major problem of cam designing is determining the best follower motion to accomplish the job. Many factors need to be considered when specifying a particular motion. For instance, many curves which are satisfactory for slow speed cams result in large acceleration and vibration forces if the cam is run at high speeds.

In determining follower motion for low speed cams, three types of motion are used — straight line or constant velocity, parabolic or constant acceleration, and simple harmonic motion. Before discussing the particular motions mentioned above, some criteria for design of low speed cams should be discussed.

The conditions under which low speed cams are run permit enough laxity in design that no great problems are encountered. Perhaps the most important specification for low speed cams is that there be no discontinuities present. The reasoning behind this should be obvious so continuity will be assumed on all cams. It is also desired that there be no sharp changes of direction on the cam surface. Even at low speeds a configuration of this type can cause bumping which will result in breakage of the follower mechanism.

Constant velocity motion is a very simple motion but it is also very impractical. As the name implies, the follower moves with constant velocity throughout its motion. This is impractical because it causes sharp changes in direction of the cam surface at the endpoints of the motion. If this type of motion is used, the endpoints are smoothed to eliminate the bumping.

Constant acceleration motion is a motion that is often used on low speed cams because there is no sharp change in direction of the cam surface and consequently, no bumping. The curve is completely smooth, and this motion is often used.

Simple harmonic motion also gives a smooth curve and good low speed characteristics. Simple harmonic motion is very popular and is perhaps the most common type of motion. There is no preference between the last two types of motion for low speed cams, but high speed applications provide some differences.

DESIGN CRITERIA FOR CAMS

After having been introduced to definitions of the basic terms encountered in cam design, we will now discuss the criteria used for high speed cam designing. The criteria used will be dependent upon the assumption made determining speed and base circle diameter. We will assume an angular speed of 500 revolutions per minute and a base circle diameter of 3.00 inches. An angular rotation of 500 revolutions per minute is within the realm of high speed cam design and will be treated accordingly.

When considering high speed cams, the most important element is that peak acceleration should be held as small as possible. Acceleration is to be minimized because forces on the follower are directly proportional to its acceleration. The proportion under consideration is Newton's Second Law expressed as F=ma. The result of minimizing acceleration is a lessening of the force on the follower with correspondingly less change of follower breakage. Another important result is a considerable decrease in wear of the cam surface.

--Continued on Page 18

STUDENT ACTIVITIES FEE - OPTIONAL OR MANDATORY?

We, the Engineers' Council, representing the consensus of the students of The George Washington University School of Engineering and Applied Science, recommend that the compulsory activities fee proposed by the Student Council not be adopted for the following reasons:

1. A person should not be forced to pay for a service he does not wish to receive or for an activity in which he will not be able to participate.
2. Large amounts of money alone will not guarantee successful activities. We believe that the criterion for success should be based upon student reaction and student participation.
3. A guaranteed income will lessen the incentive to continually provide more worthwhile student activities and will increase the possibility that these activities will not reflect the desires of the student.
4. The budget offered with the proposed activities fee is in part unsound. To justify the fee, the Student Council must assume that all students paying the fee will participate in all activities. To accommodate the almost three thousand students who will pay the fee, there must be at least two performances of all activities held in Lisner Auditorium. The proposed budget does not provide for a second performance of all such activities.

Furthermore, believing that the majority of the students are opposed to a compulsory fee, we recommend that a referendum be held. We sincerely hope that students will exercise their right to vote and that the activities fee will be defeated, or passed, by a majority of all those affected by the fee.

Realizing that there is a need for improvement in student activities at our University, we offer the following alternatives to the proposed activities fee.

1. A large working fund provided by the University for the Student Council: We point out that this system would require each activity to be self-supporting, and that money would be paid back into the fund to maintain it. This system has the advantages of providing the Student Council with sufficient money, far enough in advance, to plan and secure talent for its activities, while at the same time requiring the Council to consider carefully the type of activities it sponsors, so that they will be well attended and so that this money can be recovered.
2. A single, optional fee to cover the entire cost, to the student, of all student activities: To encourage people to pay this fee, the Student Council should offer certain advantages, such as reduced costs, choice seating, and whatever other inducements the Council feels are necessary. This, in effect, would be an expansion and an improvement of the present campus combo, an idea which we endorse.

(This fee will affect only full-time students. We believe we represent the views of the majority of such full-time, engineering students. We encourage comments on our stand.)

AND APPLIED SCIENCE—Continued from Page 5

Each student will have to determine his exact position by September of 1963. It will not be possible to enter the new curriculum after the fall semester; however, students who do not graduate before June of 1966 will automatically be placed in the new program. During registration for the fall semester, each student now enrolled will have to fill out a card stating his decision, and, if he enters the new program, the level at which he will enter. Students with 60 hours or more will enter the Intermediate level; those with 90 hours or more will enter the Advanced level. In neither case will the comprehensive evaluation be required.

Whatever decision he makes, the student now enrolled will feel the effects of the new system. He will no longer refer to instructors of ME, CE, or EE, since separate departments have been abandoned in favor of a unified and more closely knit staff of engineering and applied science professors. He will no longer take courses such as ME 113 (Thermodynamics), or CE 132 (Fluid Mechanics); rather, he will register for Engineering 30, or Applied Science 63. Neither will he be a student of engineering; he will be a student of engineering — and applied science.

The new curriculum will have an even greater effect on those who choose to enter it. The most far-reaching is the emphasis on the individual. "This program recognizes the individual student as the most important single element in the educational process. As individuals are distinctive, there can be no single educational formula or pattern by which the student moves toward professional competence." In view of this, each student assumes the responsibility of formulating his own pattern of education. And through this increased responsibility he will develop greater imagination and creativity in preparation for higher learning and in "comprehension of values and understanding of man's heritage."

If there are any questions concerning the new program, submit them, in written form, to an Engineers' Council member or to a member of the Mecheleciv staff, or place them in the suggestion box located in the North end of Tompkins Hall on the landing between the first and second floors. If a substantial number of questions are received, both questions and answers will be published in the next issue of Mecheleciv.

Also, if sufficient interest is shown, we will also publish a list correlating present course numbers with the new designations.

A freshman foreign offairs mojor, a member of the Hatchet staff, o worker for the Bye Bye Birdie production, o pledge of Kappo Alpha Theta, the vice-President of her pledge closs, o member of the Dance Production Group ---meet lovely Gail Kingsbury.

MECH MISS

Gail Kingsbury

CONVERSION FACTORS

FOR YOUR NOTEBOOK

MULTIPLY	BY	TO OBTAIN
Abamperes	10	amperes.
Abamperes	3×10^{10}	statamperes.
abamperes per sq. cm.	64.52	amperes per sq. inch.
abampere-turns	10	ampere-turns
abampere-turns	12.57	gilberts
abampere-turns per cm.	25.40	ampere-turns per inch
abcoulombs	10	coulombs.
abcoulombs	3×10^{10}	statcoulombs
abcoulombs per sq. cm.	64.52	coulombs per sq. inch.
abfarads	10^{9}	farads
abfarads	10^{15}	microfarads.
abfarads	9×10^{20}	statfarads.
abhenries	10^{-9}	henries
abhenries	10^{-6}	milihenries.
abhenries	$1/9\times10^{-20}$	stathenries.
abmhos per cm. cube	1.662×10^{2}	mhos per mil foot.
abmhos per cm. cube	10^{3}	megmhos per cm. cube.
abohms	10^{-15}	megohms
abohms	10^{-3}	microhoms.
abohms	10^{-9}	ohms.
abohms	$1/9\times10^{-20}$	statohms.
abohms per cm. cube	10^{-3}	microhms per cm. cube.
abohms per cm. cube	6.015×10^{-3}	ohms per mil foot.
abvolts	$1/3\times10^{-10}$	statvolts.
abvolts	10^{-8}	volts.
acres	43,560	square feet.
acres	4047	square meters.
acres	1.562×10^{-3}	square miles.
acres	5645.38	square varas.
acres	4840	square yards.
acre-feet	43,560	cubic-feet.
acre-feet	3.259×10^{5}	gallons.
amperes	1/10	abamperes.
amperes	3×10^{9}	statamperes.
amperes per sq. cm	6.452	amperes per sq. inch.
amperes per sq. inch	0.01550	abamperes per sq. cm.
amperes per sq. inch	0.1550	amperes per sq. cm.
amperes per sq. inch	4.650×10^{8}	statamperes per sq. cm.
ampere-turns	1/10	abampere-turns
ampere-turns	1.257	gilberts.
ampere-turns per cm.	2.540	ampere-turns per in.
ampere-turns per inch	0.03937	abampere-turns per cm.
ampere-turns per inch	0.3937	ampere-turns per cm.
ampere-turns per inch	0.4950	gilberts per cm.
areas	0.02471	acres.
areas	100	square meters.
atmospheres	76.0	cms. of mercury.
atmospheres	29.92	inches of mercury.
atmospheres	33.90	feet of water.
atmospheres	10.333	kgs. per sq. meter.
atmospheres	14.70	pounds per sq. inch.
atmospheres	1.058	tons per sq. foot.
Bars	9.870×10^{-7}	atmospheres.
Bars	1	dynes per sq. cm.
Bars	0.01020	kgs. per sq. meter.
Bars	2.089×10^{-3}	pounds per sq. foot
Bars	1.450×10^{-5}	pounds per sq. inch.
board-feet	144 sq. in.x1 in.	cubic inches.
British thermal units	0.2530	kilogram-calories.
British thermal units	777.5	foot-pounds.
British thermal units	3.927×10^{-4}	horse-power-hours.
British thermal units	1054	joules.
British thermal units	107.5	kilogram-meters.
British thermal units	2.928×10^{-4}	kilowatt-hours.
B.t.u. per min	12.96	foot-pounds per sec.
B.t.u. per min	0.02356	horse-power.
B.t.u. per min	0.01757	kilowatts.
B.t.u. per min	17.57	watts.
B.t.u. per sq. ft. per min.	0.1220	watts per square inch.
bushels	1.244	cubic feet.
bushels	2150	cubic inches.
bushels	0.03524	cubic meters.
bushels	4	pecks.
bushels	64	pints (dry).
bushels	32	quarts (dry)
Centares	1	square meters.
centigrams	0.01	grams.
centilters	0.01	liters.
centimeters	0.3937	inches.
centimeters	0.01	meters.
centimeters	393.7	mils.
centimeters	10	millimeters.
centimeter-dynes	1.020×10^{-3}	centimerer-grams.
centimeter-dynes	1.020×10^{-8}	meter-kilograms.
centimeter-dynes	7.376×10^{-8}	pound-feet.
centimeter-grams	980.7	centimeter-dynes.
centimeter-grams	10^{-5}	meter-kilograms.
centimeter-grams	7.233×10^{-5}	pound-feet.

MULTIPLY	BY	TO OBTAIN
centimeters of mercury	0.01316	atmospheres.
centimeters of mercury	0.4461	feet of water.
centimeters of mercury	136.0	kgs. per square meter.
centimeters of mercury	27.85	pounds per sq. foot.
centimeters of mercury	0.1934	pounds per sq. inch.
centimeters per second	1.969	feet per minute.
centimeters per second	0.03281	feet per second.
centimeters per second	0.036	kilometers per hour.
centimeters per second	0.6	meters per minute.
centimeters per second	0.02237	miles per hour.
centimeters per second	3.728×10^{-4}	miles per minute.
cms. per sec. per sec.	0.03281	feet per sec. per sec.
cms. per sec. per sec.	0.036	kms. per hour per sec
cms. per sec. per sec.	0.02237	miles per hour per se
circular mils	5.067×10^{-6}	square centimeters.
circular mils	7.854×10^{-7}	square inches.
circular mils	0.7854	square mils.
cord-feet	4 ft.x4 ft.x1 ft.	cubic feet.
cords	8 ft.x4 ft.x4 ft.	cubic feet.
coulombs	1/10	abcoulombs.
coulombs	3×10^{9}	statcoulombs.
coulombs per sq. inch	0.01550	abcoulombs per sq. cm
coulombs per sq. inch	0.1550	coulombs per sq. cm.
coulombs per sq. inch	4.650×10^{8}	statcouls per sq. cm.
cubic centimeters	3.531×10^{-5}	cubic feet.
cubic centimeters	6.102×10^{-2}	cubic inches.
cubic centimeters	10^{-6}	cubic meters.
cubic centimeters	1.308×10^{-6}	cubic yards.
cubic centimeters	2.642×10^{-4}	gallons.
cubic centimeters	10^{-3}	liters.
cubic centimeters	2.113×10^{-3}	pints (liq.)
cubic centimeters	1.057×10^{-3}	quarts (liq.)
cubic feet	2.832×10^{4}	cubic cms.
cubic feet	1728	cubic inches.
cubic feet	0.02832	cubic meters.
cubic feet	0.03704	cubic yards.
cubic feet	7.481	gallons.
cubic feet	28.32	liters.
cubic feet	59.84	pints (liq.)
cubic feet	29.92	quarts (liq.)
cubic feet per minute	472.0	cubic cms. per sec.
cubic feet per minute	0.1247	gallons per sec.
cubic feet per minute	0.4720	liters per second.
cubic feet per minute	62.4	lbs. of water per min
cubic inches	16.39	cubic centimeters.
cubic inches	5.787×10^{-4}	cubic feet
cubic inches	1.639×10^{-5}	cubic meters.
cubic inches	2.143×10^{-5}	cubic yards.
cubic inches	4.329×10^{-3}	gallons.
cubic inches	1.639×10^{-2}	liters.
cubic inches	0.03463	pints (liq.)
cubic inches	0.01732	quarts (liq.)
cubic meters	10^{6}	cubic centimeters
cubic meters	35.31	cubic feet.
cubic meters	61.023	cubic inches.
cubic meters	1.308	cubic yards.
cubic meters	264.2	gallons.
cubic meters	10^{3}	liters.
cubic meters	2113	pints (liq.)
cubic meters	1057	quarts (liq.)
cubic yards	7.646×10^{5}	cubic centimeters
cubic yards	27	cubic feet.
cubic yards	46.656	cubic inches.
cubic yards	0.7646	cubic meters.
cubic yards	202.0	gallons.
cubic yards	764.6	liters.
cubic yards	1616	pints (liq.)
cubic yards	807.9	quarts (liq.)
cubic yards per minute	0.45	cubic feet per secon
cubic yards per minute	3.367	gallons per second.
cubic yards per minute	12.74	liters per second.
Days	24	hours.
Days	1440	minutes.
Days	86,400	seconds.
decigrams	0.1	grams.
deciliters	0.1	liters.
decimeters	0.1	meters.
degrees (angle)	60	minutes.
degrees (angle)	0.01745	radians.
degrees (angle)	3600	seconds.
degrees per second	0.01745	radians per second.
degrees per second	0.1667	revolutions per min
degrees per second	0.002778	revolutions per sec
dekagrams	10	grams.
dekaliters	10	liters.
dekameters	10	meters.
dollars (U.S.)	5.182	francs (French).
dollars (U.S.)	4.20	marks (German)
dollars (U.S.)	0.2055	pounds sterling (Bri
dollars (U.S.)	4.11	shillings (British)
drams	1.772	grams.
drams	0.0625	ounces.
dynes	1.020×10^{-3}	grams.
dynes	7.233×10^{-5}	pounds.

MULTIPLY	BY	TO OBTAIN
pounds per mil foot	2.306×10^{6}	grams per cubic cm.
pounds per square foot	0.01602	feet of water.
pounds per square foot	4.882	kgs. per square meter.
pounds per square foot	6.944×10^{-3}	pounds per sq. inch.
pounds per square inch	0.06804	atmospheres.
pounds per square inch	2.307	feet of water.
pounds per square inch	2.036	inches of mercury.
pounds per square inch	703.1	kgs. per square meter.
pounds per square inch	144	pounds per sq. foot.
Quadrants (angle)	90	degrees.
Quadrants (angle)	5400	minutes.
Quadrants (angle)	1.571	radians.
quarts (dry)	67.20	cubic inches.
quarts (liq.)	57.75	cubic inches.
quintals	100	pounds.
quires	25	sheets.
Radians	57.30	degrees.
Radians	3438	minutes.
Radians	0.637	quadrants.
radians per second	57.30	degrees per second.
radians per second	0.1592	revolutions per second.
radians per second	9.549	revolutions per min.
radians per sec. per sec.	573.0	revs. per min. per min.
radians per sec. per sec.	9.549	revs. per min. per sec.
radians per sec. per sec.	0.1592	revs. per sec. per sec.
reams	500	sheets.
revolutions	360	degrees.
revolutions	4	quadrants.
revolutions	6.283	radians.
revolutions per minute	6	degrees per second.
revolutions per minute	0.1047	radians per second.
revolutions per minute	0.01667	revolutions per sec.
revs. per min. per min	1.745×10^{-3}	rads. per sec. per sec.
revs. per min. per min	0.01667	revs. per sec. per sec.
revs. per min. per min	2.778×10^{-4}	revs. per min. per sec.
revolutions per second	360	degrees per second.
revolutions per second	6.283	radians per second.
revolutions per second	60	revs. per min.
revs. per sec. per sec	6.283	rads. per sec. per sec.
revs. per sec. per sec	3600	revs. per min. per min.
revs. per sec. per sec	60	revs. per min. per sec.
rods	16.5	feet.
Seconds (angle)	4.848×10^{-6}	radians.
spheres (solid angle)	12.57	steradians.
spherical right angles	0.25	hemispheres.
spherical right angles	0.125	spheres.
spherical right angles	1.571	steradians.
square centimeters	1.973×10^{5}	circular mils.
square centimeters	1.076×10^{-3}	square feet.
square centimeters	0.1550	square inches.
square centimeters	10^{-6}	square meters.
square centimeters	100	square millimeters.
sq. cms.-cms. sqd	0.02402	sq. inches-inches sqd.
square feet	2.296×10^{-5}	acres.
square feet	929.0	square centimeters.
square feet	144	square inches.
square feet	0.09290	square meters.
square feet	3.587×10^{-8}	square miles.
square feet	.1296	square varas.
square feet	1/9	square yards.
sq feet-feet sqd	2.074×10^{4}	sq. inches-inches sqd.
square inches	1.273×10^{6}	circular mils.
square inches	6.452	square centimeters.
square inches	$6.9.44 \times 10^{-3}$	square feet.
square inches	10^{6}	square mils.
square inches	645.2	square millimeters.
sq inches-inches sqd	41.62	sq. cms.-cms. sqd.
sq inches-inches sqd	4.823×10^{-5}	sq. ft.-feet sqd.
square kilometers	247.1	acres.
square kilometers	10.76×10^{6}	square feet.
square kilometers	10^{6}	square meters.
square kilometers	0.3861	square miles.
square kilometera	1.196×10^{6}	square yards.
square meters	2.471×10^{-4}	acres.
square meters	10.764	square feet.
square meters	3.861×10^{-7}	square miles.
square meters	1.196	square yards.
square miles	640	acres.
square miles	27.88×10^{6}	square feet.
square miles	2.590	square kilometers.
square miles	3,613,040.45	square varas.
square miles	3.098×10^{6}	square yards.
square millimeters	1.973×10^{3}	circular mils.
square millimeters	0.01	square centimeters.
square millimeters	1.550×10^{-3}	square inches.
square mils	1.273	circular mils.
square mils	6.452×10^{-6}	square centimeters.
square mils	10^{-6}	square inches.
square varas	.0001771	acres.
square varas	7.716049	square feet.
square varas	.0000002765	square miles.
square varas	.857339	square yards.
square yards	2.066×10^{-4}	acres.
square yards	9	square feet.
square yards	0.8361	square meters.
square yards	3.228×10^{-7}	square miles.
square yards	1.1664	square varas.
statamperes	$1/3 \times 10^{-10}$	abamperes.
statamperes	$1/3 \times 10^{-9}$	amperes.
statcoulombs	$1/3 \times 10^{-10}$	abcoulombs.
statcoulombs	$1/3 \times 10^{-9}$	coulombs.
statfarads	$1/9 \times 10^{-20}$	abfarads.
statfarads	$1/9 \times 10^{-11}$	farads.
statfarads	$1/\times 10^{-5}$	microfarads.
stathenries	9×10^{20}	abhenries.
stathenries	9×10^{11}	henries.
stathenries	9×10^{14}	millihenries.
statohms	$9/10^{20}$	abohms.
statohms	9×10^{5}	megohms.
statohms	9×10^{17}	microhms.
statohms	9×10^{11}	ohms.
statvolts	3×10^{10}	abvolts.
statvolts	300	volts.
steradians	0.1592	hemispheres.
steradians	0.07958	spheres.
steradians	0.6366	spherical right angles.
steres	10^{3}	liters.
Temp. (degs. C)+273	1	abs. temp. (degs. C.)
Temp. (degs. C.)+17.8	1.8	temp. (degs. Fahr.).
temp (degs. F.)+460	1	abs. temp. (degs. F.).
temp. (degs. F.)—32	5/9	temp. (degs. Cent.).
tons (longs)	1016	kilograms.
tons (longs)	2240	pounds.
tons (metric)	10^{3}	kilograms.
tons (metric)	2205	pounds.
tons (short)	907.2	kilograms.
tons (short)	2000	pounds.
tons (short) per sq. ft	9765	kgs. per square meter.
tons (short) per sq. ft	13.89	pounds per sq. inch.
tons (short) per sq. in	1.406×10^{6}	kgs. per square meter.
tons (short) per sq. in	2000	pounds per sq. inch.
Varas	2.7777	feet.
Varas	33.3333	inches.
Varas	.000526	miles.
Varas	.9259	yards.
volts	10^{8}	abvolts.
volts	1/300	statvolts.
volts per inch	3.937×10^{7}	abvolts per cm.
volts per inch	1.312×10^{-3}	statvolts per cm.
Watts	0.05692	B.t. units per min.
Watts	10^{7}	ergs per second.
Watts	44.26	foot-pounds per min.
Watts	0.7376	foot-pounds per sec.
Watts	1.341×10^{-3}	horse-power.
Watts	0.01434	kg.-calories per min.
Watts	10^{-3}	kilowatts.
watt-hours	3.415	British thermal units.
watt-hours	2655	foot-pounds.
wstt-hours	1.341×10^{-3}	horse-power-hours.
watt-hours	0.8605	kilogram-calories.
watt-hours	367.1	kilogram-meters.
watt-hours	10^{-3}	kilowatt-hours.
webers	10^{8}	maxwells.
weeks	168	hours.
weeks	10,080	minutes.
weeks	604,800	seconds.
Yards	91.44	centimeters.
Yards	3	feet.
Yards	36	inches.
Yards	0.9144	meters.
Yards	1.08	varas.
years (common)	365	days.
years (common)	8760	hours.
years (leap)	366	days.
years (leap)	8784	hours.

TECH NEWS

Edited by Clifford B. Stearns

This small hollow cylinder actually performs the same basic function as the familiar spinning gyroscope silhouetted behind it. Developed by scientists at the Westinghouse Research Laboratories, it is the first successful solid-state gyro and is particularly suited for applications in space. Microscopic vibrations set up in the cylinder correspond to the spin of the wheel of a conventional gyro. Any move to rotate the cylinder out of position adds a lengthwise twist to its vibrating motion. This twist can be used to control the attitude of a satellite or other vehicle in space and, in principle, duplicates exactly the twist developed in a "twister" doing the popular dance.

GYROSCOPE THAT DOES THE TWIST

Westinghouse scientists have invented a gyroscope that "does the twist." It is extremely useful in outer space and represents the first successful solid-state gyro. The gyro bears little resemblance to a conventional gyroscope with its rotating wheel that spins like a top. It is simply a solid thin-wall hollow cylinder, pressed from ceramic powder and suspended from a point midway between its two open ends. The lengthwise twist developed by the cylinder is what makes it useful as a gyro. This twist arises for the same physical reason that body twisting arises when developed in the popular dance, the "twist."

The new gyroscope is a cylinder of only half an inch long and half an inch in diameter. It takes less than a thousandth of a watt of electric power to drive it. But, like a rotating-wheel gyroscope, it has the same ability to act as a reference in space, detecting any motion that tends to swing it from its position. This is the property that has made the gyroscope the standard sensor for the guidance and control of almost everything that flies — aircraft, missiles, satellites and manned spacecraft.

The gyro, a type broadly classed as a vibrating gyroscope, or vibragyro, was developed under the direction of a research engineer, with further development being carried out by Westinghouse Defense Center's Air Arm Division, Baltimore, Md. Since it has no rotating parts, the solid-state gyro should be especially suitable for applications in the weightless, ultra-high vacuum conditions of outer space. The solid-state gyro substitutes back-and-forth radial motion of a cylinder for the rotary motion of a wheel. The radial motion is obtained by exciting the cylinder with a small high-frequency voltage. The cylinder is made from a material, such as barium titanate, which can convert the applied voltage into mechanical vibrations and, inversely, mechanical vibrations back into electricity. This same principle (piezoelectric effect) is found in the crystal pickup of an ordinary record player. In vibrating, the open ends of the gyro cylinder expand and contract in opposite directions 100,000 times a second. The actual movement is so small that it cannot be detected by an ordinary microscope. Once the cylinder is vibrating, it detects any move to rotate it about its axis and responds by adding a (right-angle) lengthwise twist to its motion. This action produces the useful electrical signal that is picked off and amplified, as in the case of the phono pickup.

Westinghouse uses the word "twist" to explain this new innovation because of the mechanical behavior of the cylinder. The out-of-phase vibrations of the ends of the cylinder correspond to the motion of the dancer's arms and legs. These give rise to a torsional vibration along the longitudinal axis of the cylinder, corresponding to the dancer's backbone. If the cylinder is aligned with the axis of a space vehicle or aircraft, it detects any drift about that axis and gives electrical signals to correct it. Simply by proper mounting, the gyro can stabilize the vehicle for left-and-right motion (yaw), up-and-down motion (pitch) or corkscrew motion (roll).

Future plans for the invention include applications for controlling the yaw of a space satellite. It would be capable of measuring the extremely slow rates of drift required for such control; it would have a long, dependable life in this difficult environment; and its flea-sized power requirements can be met by solar cells or other weak electrical sources now available in such spacecraft.

A CONTINUOUS ORBITAL GUIDANCE SYSTEM

A new electronic system to tell astronauts their exact location after first orbit is under development by the General Electric engineers. Hence, multiple orbits will not be necessary to obtain the information on location of the spacecraft. Continuous orbital guidance system, called COGS, will fit entirely into a spacecraft or satellite and weighs 20 to 30 pounds. It will detect and correct a space vehicle's deviation from intended orbit and provide astronauts or ground control centers with the vehicle's altitude, period of orbit and ellipticity. Its basic equipment is a radar altimeter and a simple digital computer.

—Continued on Page 16

THE BELL TELEPHONE COMPANIES SALUTE: BILL TYLER

Bill Tyler (B.S.E.E., 1958) is an Engineer with Southern Bell in Louisville. His specialty is telephone power equipment. Recently he engineered power plant replacements valued at nearly $300,000.

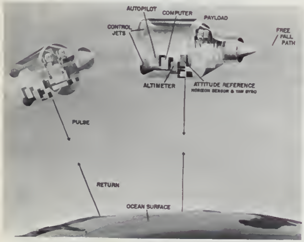
Previously, Bill was an Equipment Engineer. In that job he prepared specs for power, carrier and repeater, teletypewriter and other equipment. On a special assignment, he taught a magnetics theory course to high school science teachers. After hours, Bill joins other telephone people in fixing "Talking Machines" for the blind.

Bill Tyler and other young engineers like him in Bell Telephone Companies throughout the country help bring the finest communications service in the world to the homes and businesses of a growing America.

BELL TELEPHONE COMPANIES

TECH NEWS—Continued from Page 14

The altimeter is a modified beacon already in use in other guidance systems. This new device can continuously measure satellite or spacecraft altitudes while passing over water (three-quarters of the time of a typical Earth orbit). These measurements establish the spacecraft's radius from Earth's center of gravity. From the record of the vehicle's altitude during its first orbit compared with its intended orbit or trajectory, COGS can determine the actual course of the vehicle. The technique involved has already been shown capable of operating up to altitudes of 6000 miles from Earth. COGS, also, is capable of measuring spaceship altitude accurately within a few feet.



"MASERS, LASERS, RAZORS, . . ."

You have probably heard much about special gasses and ruby crystals that can be made to emit coherent radiation at the high end of the electromagnetic spectrum. Science now promises to bring the laser out of the laboratory.

A news release from Corning Glass Works, dated October 14, reveals that a physicist at Corning has achieved laser action at 9180 angstroms (infrared) in a neodymium-doped soda lime silicate base glass. A release from Eastman Kodak Company, reaching my desk about a week later, says that Kodak has achieved laser action at 10,600 angstroms (infrared) in a neodymium-doped rare-earth glass which does not require refrigeration. The use of a glass host media offers lower cost, easier control of doping composition, and easier manufacture than with previous lasering materials.

General Electric Corporation has taken a somewhat different approach to the problem. A release, dated November 1, states that G. E. Research Laboratory has tested a gallium-arsenide diode, about the size of a small transistor, which emits coherent infrared light (at 8400 angstroms) when excited by a current. Since currents as high as 20,000 amperes per square centimeter are required, the current must be pulsed and the crystal refrigerated.

COMPUTERS FOR CAM DESIGN—continued from Page 7

Another consideration for high speed cam design is that jerk or the time rate of change with respect to time of acceleration should be finite. Jerk is a direct measure of vibration effects of the system and was until recently completely neglected. The fact that the effect of jerk is somewhat diminished is seen from the consideration that all finite values of jerk can be allowed. It is only when jerk becomes infinite that it becomes a serious problem. The result of infinite jerk on high speed cams is a considerable amount of vibration in the system. Vibration can easily cause serious damage to the cam surface and initiate breakage in the follower mechanism. Despite the fact that all finite values of jerk can be tolerated, it is desired that values be kept as small as possible.

Now, having established the criteria for cam designing, we will observe previous methods of designing cams. The longstanding method of designing cams is graphic design. This method consists of drawing a displacement diagram using some simple motion like simple harmonic or constant acceleration motion. Once the displacement diagram is obtained, the pitch curve can be drawn by transferring the linear displacements to circular displacements plus the base circle radius. (Figure 2) It is evident that the graphic method is very inaccurate and slow. The accuracy of the cam is limited by the accuracy of the drawing to slow moving cams. Graphic design is a slow process and does not lend itself well to modern production methods. In addition to its other disadvantages, graphic design cannot be used for any of the advanced curves because the curves cannot be represented by graphic methods.

A method of cam design that is used very much today is to set up mathematical expressions for the displacement curve and then calculate the actual displacement by hand. A desk calculator often helps but often various trigonometeric functions are involved which cannot be worked on the calculator. Since modern cams often require complex displacement formulas, hand calculation can become a very long and laborious process.

Now, having established a definite need for a modern method of designing cams, we will see how well a high speed digital computer is adapted to do the job. Of course, the main advantage is the high speed of the computer. This capability allows the use of the same method as before but within feasible time limits. All of the computations for displacement are handled quickly in addition to expressions for velocity, acceleration, and jerk. More advanced curves are no problem in this case because they can be handled easily with proper programming.

The use of computers allows analyses of more advanced types of motion with correspondingly better designs. Curves can now be chosen which would give reasonable values for acceleration and jerk. These curves can be integrated to produce a displacement curve. Once the displacement curve is obtained, the values of displacement for various degrees of rotation can be quickly computed to give the desired results. The results of computation give the displacement diagram and finally the pitch circle. The values for displacement are the desired values. The formulas for displacement, acceleration, and jerk are given in the following order; Simple Harmonic Motion, Cycloidal Motion, Double Harmonic Motion, and Fifth Order Polynomial:

Displacement	Acceleration	Jerk
$y = \frac{h}{2}\left(1 - \cos\frac{\pi\theta}{\beta}\right)$	$a = \frac{h}{2}\left[\left(\frac{\pi w}{\beta}\right)^2 \cos\frac{\pi\theta}{\beta}\right]$	$j = -\frac{h}{2}\left(\frac{\pi w}{\beta}\right)^3 \sin\frac{\pi\theta}{\beta}$
$y = \frac{h}{\pi}\left(\frac{\pi\theta}{\beta} - \frac{1}{2}\sin\frac{2\pi\theta}{\beta}\right)$	$a = \frac{2h}{\pi}\left(\frac{\pi w}{\beta}\right)^2 \sin\frac{2\pi\theta}{\beta}$	$j = \frac{4h}{\pi}\left(\frac{\pi w}{\beta}\right)^3 \cos\frac{2\pi\theta}{\beta}$
$y = \frac{h}{2}\left[\left(1 - \cos\frac{\pi\theta}{\beta}\right) - \frac{1}{4}\left(1 - \cos\frac{2\pi\theta}{\beta}\right)\right]$	$a = \frac{h}{2}\left(\frac{\pi w}{\beta}\right)^2\left(\cos\frac{\pi\theta}{\beta} - \cos\frac{2\pi\theta}{\beta}\right)$	$j = \frac{h}{2}\left(\frac{\pi w}{\beta}\right)^3\left(2\sin\frac{2\pi\theta}{\beta} - \sin\frac{\pi\theta}{\beta}\right)$
$y = h\left(1 - \frac{10}{3}\phi^2 + 5\phi^4 - \frac{8}{3}\phi^5\right)$	$a = h\left(\frac{w}{\beta}\right)^2\left(-\frac{20}{3} + 60\phi - \frac{160}{3}\phi\right)$	$j = h\left(\frac{w}{\beta}\right)^3\left(120\phi - 160\phi^2\right)$

WHERE FOR $h > 0$, $\phi = 1 - \frac{\theta}{\beta}$ AND FOR $h < 0$, $\phi = \frac{\theta}{\beta}$.

PROGRAM PARAMETERS

A general IBM FORTRAN program was written for the calculation of design parameters for given boundary conditions. Four types of motion are selected by the use of console sense switches; simple harmonic, double harmonic, cycloidal, and fifth-order polynomial motions. Input is by punched card and output is on a printer or typewriter.

Data for the program are loaded in the following manner:

1. Each problem has a leader card on which is punched:

Col. 1	Number of segments of the cam
Cols. 2-11	Increment of rotation in degrees
Cols. 12-21	Cam speed in R.P.M.
Cols. 22-31	Radius of base circle in the working units (inches, feet, etc.).

2. This leader card is followed by a number of follower cards, one for each segment, on which is punched:

Cols. 1-10	Change in follower displacement desired in the segment, in the working units
Cols. 11-20	End point of the segment in degrees

These groups of design specification cards may be stacked in the reader and the segments processed sequentially. When all the data for a segment are read in, the computer so indicates and waits for proper sense switches to be set. The sense switches are set accordingly:

1	Fifth order polynomial motion
2	Cycloidal motion
1 & 2	Simple harmonic motion
1 & 3	Double harmonic motion
none	All types of motion will be calculated and printed.

Then the computer is started and that segment will be processed and printed.

For a complete analysis, six columns of numbers are printed.

First	Angle of rotation (degrees)
Second	Follower displacement from the base circle (inches)
Third	Follower velocity
Fourth	Follower acceleration
Fifth	Follower jerk
Sixth	Pressure angle tangent

After each segment is processed, the computer halts and switches may then be set for the next segment. After the final segment is completed, the machine halts. To obtain results for a different problem, all that is required is to load in new data and press start.

ADVANTAGES OF COMPUTER DESIGN

The advantages of using a computer to design cams stem from several important considerations. First of all, greater accuracy is realized with none of the extra labor that is encountered in hand design. The greatest usable manufacturing accuracy can be obtained by the computer with no difficulty. The closest tolerance normally used in cam manufacture is ± 0.0002 inches which is readily achieved by the computer. Second, a more complete analysis is obtained by a well-compiled program. The expression for jerk is usually the one that is chosen instead of an expression for displacement. Then the other expressions can be determined by integrating the curves to obtain values for acceleration, velocity, and displacement. Having the computer give values of displacement, acceleration and jerk gives the designer sufficient information to make a precise analysis. The program was set up to accept input data giving height and length of each portion of cam action. This could be varied to give any combination of conditions desired. The output included values for displacement, velocity, acceleration, jerk, and the tangent of the pressure angle. The inclusion of all of the above information allows a very complete analysis of the follower action. The third and perhaps most important result is the speed of the computations. After the program is written, all that is required is that a few cards punched with the input information be read into the computer. The specifications for the cam are printed out within a few seconds, and many hours of computation and analysis are saved.

In order to be a commercially effective program, the displacement curve should be converted from the pitch curve to the working curve. The working curve is desired because it is the actual surface that will be machined on the cam. The reason that this was not included was that it added nothing to the program, while it would have complicated it considerably. In addition, the follower geometry would have had to have been assumed, which is not desirable. If the program were to be used commercially, the follower geometry would be part of the input data and the dimensions of the working curve would be printed out.

In the near future, one further advantage of computer design may be realized. The computer can be instructed to punch a paper tape which will guide a machine directly to produce the desired cam profile. With the announcement of the autospot programming aid, the punched tape is now available. All that remains now is to complete the development of a machine that will produce the cam from the tape.

Due to its length and complexity, the program was not included. However, the program and also sample data printout are available upon request to the author. As was indicated, the program was written in format FORTRAN for use on the IBM 1401 and 1620 computers. Credits are due to Mike Armstrong and Bill Burleigh who also worked on the project.

CAMPUS NEWS

SOCIETY NEWS

At the November meeting of the ASCE, Mr. Dennis Carter spoke on problems of communication between architects, Mechanical Engineers, and Structural Engineers. Mr. Carter is employed by Beall-LeMay Engineers.

The schedule for the ASME November meeting centered around a talk, by Doctor Snider from the National Education Association, on teaching machines and programmed learning. The talk was quite informative and well illustrated.

The AIEE-IRE members were surrounded by tubes, transistors, and other similar items when they visited the Flac II computer, located in room 100 of Tompkins Hall, for their November program. Although the machine was not in operation, its construction, operation, and application were more than amply explained and illustrated by Professor Arnold C. Meltzer, the senior member of the staff in charge of building and operating the computer.

SIGMA TAU

Sigma Tau's fall initiation was held on November 10 in Lisner Auditorium. The following new members were initiated:

Arthur Crenshaw	Sherman Min
George Devilbiss	George Morgan
Ashok Kalelkar	John Nemechek
William Kolb	Wasyl Ostaffe
Thomas McIntosh	

Then, in November, an open meeting of Sigma Tau was held for the purpose of presenting the keys to the new initiates. Dr. C. Rogers McCullough, Vice President of Nuclear Utility Services, Inc., gave a short talk on the relative merits of engineers and scientists. Dr. McCullough then presented the keys to the new members. Afterwards, Mr. Raymond R. Stootsberry, Chief of the Natural Resources Branch of the Internal Revenue Service, and newly elected alumni member of Sigma Tau, spoke on his experiences in wildcat oil drilling.

ENGINEERS' COUNCIL

During the November meeting, the Engineers' Council voted to stand opposed to the Student Council activities fee. For an explanation of this stand, see the resolution presented on page 8. Also passed was a motion to buy more bookcovers for the spring semester. Two reports concerning studies of parking conditions in the University area were presented. One stated that parking regulations are set by the Department of Highway Engineers, and are only enforced by the Police Department. Furthermore, it was reported that a study had recently been made of traffic conditions in this area, and that another study, considering any recommendations of the Council would probably not be made unless backed by the University. The second report stated that the parking regulations on the University student lots are governed by the business office. In the past the business office has tried changing the time limits so that students would not have to pay two tickets for parking in the late afternoon. However, the system did not work any better than the present one. No further action was taken by the Council at this time.

The results of the questionnaire distributed during fall registration were presented to the Council. The eight items covered in the survey were: 1) D-H House 2) Mecheleciv 3) Bookcovers 4) Decals 5) Engineers' Ball 6) Engineers' Open House 7) Engineers' Mixers 8) Awards Night. All items received over 60% approval; most items, over 75%. The Mecheleciv received the most support while the Engineers' Ball received the least support.

THETA TAU

November was a busy month for Theta Tau. On the 11th, a shrimp feast was held at the home of brother Wilkinson. The day was enjoyed by all pledges, brothers, and alumni who attended. On the 17th, a formal initiation was conducted, at which time

Michael Cogan	Tom McIntosh
Gordan Davison	Larry O'Callaghan
Ely Fishlowitz	Norman Seidle
Paul Fleming	Bill Williams

became members of Gamma Beta Chapter. Louis Boezi could not be present, but will be initiated at a later date.

In the evening, a banquet and ball was held in honor of the new initiates. The highlight of the evening was a skit, put on by the ex-pledge class, "Cape Carnival". Shown, is Mike Cogan, a visiting Russian dignitary, interviewing Yo-Yo the astronaut (alias, Paul Fleming).

The fraternity was very pleased to have as its guests at the last two functions Mr. Robert

Pope, traveling secretary of Theta Tau, and Mr. Paul Kuzio, president of the Washington Area Theta Tau Alumni Association.

INTRAMURALS

The engineers' football team completed its season with a respectable 3-1-1 record. The game of October 28 resulted in a victory for the engineers over PSD by a very close score of 7-6. In their season's finale the engineers rolled over the Med School F and S by a score of 19-0. The basketball season is just beginning and the engineering school will have a team in that event. Several members of the school participated in the foul-shooting event. Bowling leagues will soon be formed so those interested will soon be able to sign up. The list of activities is maintained on the main bulletin board in the North end of Tompkins Hall.

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58 - E, Hasbrouck Apts.
Ithaca, N. Y.
Nov. 20, 1962

Dear Dean Mason:

I want you to know that I have become extra proud in having done my undergraduate study at G.W. after reading about the completely new engineering education program which will be instituted.

My engineering experiences are limited, but they have emphatically impressed me with the fact that in industry or graduate school an engineers success is greatly dependent upon his undergraduate training. The education I received at G.W. has so far proven itself superior to that which others in my field gained elsewhere.

I think that this is due in part to the teaching skills and knowledge of the faculty, but also a great part is because you and your staff are constantly shaping and reshaping the study program to always have it meet the educational needs of the modern engineer.

This certainly marks the school as one which is keenly aware of the world in which its graduating students must live and work and is eagerly ready to give them top preparation in addition to "the degree".

This latest and most outstanding change then to me is typical in that it continues to maintain your constant interest in best preparing students for the engineering profession.

Very sincerely yours,

Steve Thau

Steve Thau

CALENDAR OF EVENTS

December

5	Professional Society Meetings 8:00 p.m.
6	G.W.U. Symphony Orchestra, Lisner Aud., 8:30 p.m.
7	Lecture in Lisner Aud. at 10:30 a.m.-2:00 p.m. - Professor Irving Kaplansky - Topic - Lie Algebras
8	Graduate Record Exam
12	Theta Tau Meeting
19	Sigma Tau Meeting
22	Christmas Recess Begins

January

3	Classes Resume
9	Theta Tau Meeting Cultural Foundation Program, Lisner Aud.
10	G.W.U. Concert Artist Series, Lisner Aud., 8:30 p.m.
11	Lecture in Lisner Aud. at 10:30 a.m.-2:00 p.m. - Professor Samuel Eilenberg - Topic - Algebraic Topology

INDEX TO ADVERTISERS

Another Night Before Christmas

'Twas the night before Christmas and all through the house,
There were empties and butts, left around by some louse,
The best quart I hid by the chimney with care
Had been swiped by same bum, who discovered it there.
My guests all had long since been poured in their beds
To wake up in the morning with awful big heads.
My mouth, full of cotton, hung down to my lap
Because I was dying for one more nightcap.
When through the north window there came such a smell
I sprang to my feet to see what the hell. . . .
And what to my wondering eyes should show up
But eight bloated reindeer, hitched to o beer truck.

With a little old driver who looked like a hick
But I saw it was Santa, as tight as a tick.
Staggering onward, those eight reindeer came,
While he hiccoughed and belched as he called them by name;
"On Schenley! On Seagram! We ain't got all night,
You, too, Haig ond Haig, and you, too, Black and White."
"Scram up on this roof, get off of this wall,
Get going you dummies, we've got a long haul."

So up on the roof went the reindeer and truck,
But a tree branch hit Santa before he could duck.
And then, in a twinkling, I heard from above
A hell of a noise that was no cooing dove.
So I pulled in my head and I cocked a sharp ear,
Down the chimney he plunged, landing smack on his rear.
He was dressed up in furs, no cuffs on his pants
And the way the guy squirmed, well, I guess he had ants.
He had pints and quarts in the sack on his back
And a breath that would blow a train off the track.
He was chubby and plump and he tried to stand right
But he didn't fool me, he was high as a kite.

He spoke not a word, but went straight ta work
Missed half the stockings, the plastered old jerk.
Then putting five fingers to the end of his nose.
He gave me the bird . . . up the chimney he rose.
He sprang for his truck at so hasty a pace
That he tripped on a gable and slid on his face . . . .
But I heard him burp back as he passed out of sight,
"Merry Christmas, you rum-dums, now really get tight."

HAPPY NEW YEAR . . .

It is customary to give gifts at Yuletide to the young, who have scant sympathy for your financial plight. A lovable big brother you had better be.

THIS WILL DO IT ➧

BROWNIE STARMITE Outfit—camera (weighing only 8 ounces including built-in flash), film, flashbulbs, batteries, instructions. First package to be opened on Christmas morning for instant fun. Useful on parties and school projects. Educational. Trot down to the nearest camera counter, take care of the matter, and get it off your mind. Doesn't cost much. Leaves you pecuniary margin in selecting a gift for the Fair One, should you be so lucky.

Kodak beyond the snapshot...
(random notes)

How to make a double bond—The man on the left joined our Synthetic Chemicals Division softball team season before last as an outfielder. The one in the middle plays very little softball. He plays center on the Synthetic Chemicals Division basketball team. The man on the right is well-acquainted with both of the other boys, since he manages *both* the softball team *and* the basketball team. In addition, he had been asked to make 1,4-diphenyl-1,3-butadiene.

The outfielder and the basketball center mentioned that they had developed a new synthesis for olefins *via* a phosphonate intermediate. Well, not exactly new but much faster, easier to work, and better yielding than the prior art had afforded.

"Give," said the manager.

"Run the Michaelis-Arbuzov reaction and make some diethyl benzylphosphonate," said the outfielder. "That's $(C_2H_5O)_2P(O)CH_2C_6H_5$. The benzyl group on it will hook on exothermically to almost any aldehyde. The carbonyl oxygen from the aldehyde and a proton from the benzyl come off, and a double bond is formed. You have to run the reaction in a strongly basic medium. The new wrinkle is to achieve the alkalinity you need by previously prepared sodium methoxide, with dimethylformamide as your solvent."

"What happens," added the kibitzer, "is the phosphonate reacts with the $NaOCH_3$ in an equilibrium reaction to form phosphonate carbanion, which then performs a nucleophilic attack on the aldehyde carbon. For what you want to do, your aldehyde would be $C_6H_5CH=CHCHO$. So you get a situation like this where the redistribution of electrons leads to formation of the new double bond and leaves sodium diethyl phosphate."

This colloquy has resulted not only in the availability of *1,4-Diphenyl-1,3-butadiene* as EASTMAN 8543 but also of the exceedingly helpful *Diethyl Benzylphosphonate* as EASTMAN 8559 and of a reprint of a short paper on the method for anybody interested. *N,N-Dimethylformamide* is EASTMAN 5870. We forget who won the ball game.

The Sun play—Neutrons aren't much good by themselves for exposing photographic materials. Yet a mere few thousand thermal neutrons/mm^2 can give decent photographic images, such as might be useful for neutron radiography (read the wine level inside a lead amphora), neutron diffraction patterns, neutron flux measurements, etc. The topic of photographic detection of neutrons is too quiet for our liking. We wish to have a little noise.

It is done by a triple play: thermal neutrons activate ^{10}B to emit alphas, which scintillate ZnS(Ag), which gives off visible light that exposes the film. For sharper images at the expense of longer exposure time, neutron fans use an activation technique involving an appreciable half-life. There are gadolinium, which works by an n,γ reaction at an optimum thickness of .074″, and dysprosium, which works by β decay at an optimum thickness of .023″. Such a neutron converter sheet is exposed without the film and then quickly pulled out of the neutron flux and put in contact with the film. Questions like "What film?" are answered by Eastman Kodak Company, X-ray Division, Rochester 4, N.Y.

A prominent role in all this has been played by a gentleman named Kuan-Han Sun, who once worked for us before his interest turned from non-silicate optical glasses to nucleonics. Married one of our x-ray researchers and took her off with him. Name was Laura McGillivray. Lovely gal.

EASTMAN KODAK COMPANY
Rochester 4, N.Y.

All sorts of products, all varieties of scientific careers at Kodak for B.S., M.S., or Ph. D.

AN INTERVIEW WITH G.E.'s DR. GUY SUITS, VICE PRESIDENT AND DIRECTOR OF RESEARCH

Dr. Suits has managerial responsibility for the General Electric Research Laboratory and as a member of the Company's Executive Office he is directly concerned with G.E.'s over-all research programs and policies. He joined G.E. in 1930 as a physicist, and holds 76 patents, is Chairman of the Directors of Industrial Research, member of the National Academy of Science, Director of American Institute of Physics, previous Chairman of Naval Research Advisory Committee and Fellow of the AIEE, AAAS, and IRE, and has been Vice President and Director of Research since 1945.

For complete information about these General Electric training programs, and a copy of Dr. Suits paper "The New Engineer And His Scientific Resources," write to: Personalized Career Planning, General Electric Company, Section 699-05, Schenectady 5, New York.

How Scientists and Engineers Work Together in Industry

Q. Dr. Suits, I've heard a good deal about the scope of your programs. Is your research mostly in physics and electronics?

A. This is a common misconception. The work of the many laboratories of General Electric "covers the waterfront" in science and in advanced engineering technology. Some laboratories specialize in electronics research, others in atomic power, space technology, polymer chemistry, jet engine technology, and so forth. Actually, the largest single field represented by the more than 1000 Ph.D. researchers in General Electric is chemistry.

Q. Is this research performed principally by people with Ph.D. degrees in science?

A. General Electric research covers a broad spectrum of basic and applied work. At the Research Laboratory we focus largely on basic scientific investigations, much as in a university, and most of the researchers are Ph.D.'s. In other Company laboratories, where the focus is on applied science and advanced engineering, engineers and scientists with B.S. and M.S. degrees predominate. Formal college training is an important preparation for research, but research aptitudes, and especially creative abilities, are also very important qualities.

Q. What are the opportunities for engineers in industrial scientific research and how do scientists and engineers work together in General Electric?

A. Classically, engineers have been concerned with the problem "how," and scientists with the question "why." This is still true, in general, although in advanced development and in technological work scientists and engineers work hand-in-hand. Very close cooperation takes place, especially in the increasingly important fields of new materials, processes, and systems. Certainly in General Electric, a person's interest in particular kinds of problems and his ability to solve them are more important than the college degree that he holds.

Q. What does it mean to an engineer to have the support of a large scientific research effort?

A. It means that the engineer has ready access to the constant stream of new concepts, new materials, and new processes that originate in research, and which may aid his effort to solve practical problems. Contact with research thus provides a "window" on new scientific developments—world-wide.

Q. How does General Electric go about hiring engineers and scientists?

A. During each academic year, highly qualified technical people from General Electric make recruiting visits to most college campuses. These men represent more than 100 General Electric departments and can discuss the breadth of G.E.'s engineering and science opportunities with the students. They try to match the interests of students and the Company, and then arrange interview visits. The result of this system is a breadth of opportunity within one company which is remarkable.

Experienced technical people are always welcome, and they are usually put in contact with a specific Company group. Where no apparent match of interests exists, referrals are made throughout General Electric. In all cases, one finds technical men talking to technical men in a really professional atmosphere.

Q. Are there training programs in research for which engineering students might be qualified?

A. There certainly are. Our 2-year Research Training Program at the General Electric Research Laboratory gives young scientists a chance to work with experienced industrial research scientists before carrying out research and development on their own.

In addition, there are seven Company-wide training programs. Those that attract the largest number of technical graduates are the Engineering and Science, Technical Marketing, and Manufacturing Training Programs. Each includes on-the-job experience supplemented by a formal study curriculum.

Of course, not all graduates are hired for training programs. In many cases, individuals are placed directly into permanent positions for which they are suited by ability and interest.

GENERAL ELECTRIC